

PREFABRICATED STAIRWAY AND METHOD

This application is a continuation-in-part of Serial No. 09/711 854 filed November 13, 2000.

FIELD OF THE INVENTION

The present invention relates to a prefabricated, plastic stairway for use between levels (e.g. floors and landings) of a building or other structure.

BACKGROUND OF THE INVENTION

A common technique for fabricating a stairway between floors of a building, such as a residential home, involves fastening wooden stringers by nails and/or brackets to floor joists and nailing wooden treads and wooden risers between the stringers to form a plurality of steps. The stringers can be fastened to the floor joist first followed by fastening of the treads and risers to the stringers, or the stringers and treads/risers can be fastened together to form a heavy stairway unit that must then be moved into position and fastened to the floor joists.

An object of the present invention is to provide an improved prefabricated stairway for use between floors and landings of a building or other structure where the stairway is relatively lightweight, requiring no special equipment to facilitate transport and proper positioning at the building or structure site, and yet sturdy enough to withstand loads encountered in use, is resistant to wear and chemicals, and offers improved stairway aesthetics.

SUMMARY OF THE INVENTION

The present invention provides in one embodiment a prefabricated stairway comprising a pair of laterally spaced apart elongated stringers adapted to be disposed between levels (e.g. floors and landings) of the building and a plurality of integral riser and tread surfaces extending between the stringer sections so as to form steps. The stringers, riser surfaces and tread surfaces are formed integrally of a plastic material. A plurality of individual preformed tread members are fastened on the tread surfaces. The tread members can be made of plastic material, wood, metal and other materials. The stairway can include an optional landing surface and landing member fastened on the landing surface proximate the top and/or bottom of the stairway.

The prefabricated stairway preferably includes a joist attachment member disposed in a laterally extending channel formed integrally on the rear side of the topmost riser surface between the stringers. The joist attachment member is thereby incorporated into the stairway and adapted to receive fasteners, such as a lag bolts, by which the stairway is fastened to a joist of a building floor or landing.

The prefabricated stairway optionally can include receptacles formed integrally along the lengths of the stringers to receive ballaster posts and newel posts of a handrail.

The prefabricated stairway preferably comprises one or more outer filled resin layers and one or more inner fiber reinforced, filled resin layers applied on the outer filler resin layer(s).

In a preferred embodiment of the invention, the tread surfaces

are configured to include an integral reinforcement surface region, such as an integral reinforcement rib extending along a length of each tread surface. The reinforcement rib has a concave cross-sectional configuration residing below a plane defined by the respective tread surface and the landing surface. The preformed tread members preferably comprise of an outer ceramic filled gelcoat layer and one or more fiber reinforced, filled resin layers and are attached to the respective tread surfaces using fasteners. The fasteners preferably are captured in part in each tread member and optional landing member during molding so as to be integral therewith.

Another embodiment of the invention envisions fastening one or more tread members to one or more steps of an existing stairway made of wood, concrete, metal and other materials. One or more tread members can be fastened to refurbish one or more worn or damaged steps. One or more colored thread members can be fastened to one or more steps to enhance the visual appearance of the step(s).

The above and other objects and advantages of the invention will become apparent from the following detailed description taken with the following drawings.

DETAILED DESCRIPTION OF THE DRAWINGS

Figure 1 is an elevational view, partially in section, of a stairway pursuant to an embodiment of the invention.

Figure 2 is a sectional view of the stairway taken along lines 2-2 of Figure 1.

Figure 3 is a sectional view of the stairway taken along lines 3-3 of Figure 1.

Figure 4 is a partial plan view of the stairway.

Figure 5 is an elevational view, partially in section, of the stairway showing the tread members with integral fasteners.

Figure 6 is an enlarged exploded partial cross-sectional view of the tread surface and tread member.

Figure 7 is an enlarged partial cross-sectional view of the sprayed plastic wall of the stairway.

Figure 8 is a side elevation of the stairway after the tread members are fastened on the tread surfaces.

Figure 9 is a front elevation, partially in section, of the stairway installed in a stairwell showing wall studs and a handrail.

Figure 10 is an elevational view, partially in section, of a free-standing stairway pursuant to another embodiment of the invention.

Figure 11 is a plan view of the stairway of Figure 10.

Figure 12 is an elevational view, partially in section, of the free-standing stairway of Figure 12 showing ballaster posts and newel posts received in receptacles of the stairway.

Figure 13 is a sectional view of the stairway taken along lines 13-13 of Figure 10.

Figure 14 is a sectional view of a preformed tread member on a wooden step.

Figure 15 is a sectional view of a preformed tread member on a concrete step.

Figure 16 is a sectional view of a preformed tread member on a metal step.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figures 1-9, a prefabricated stairway 10 pursuant to one illustrative embodiment of the invention is shown to illustrate the invention but not limit the scope of the invention. The stairway 10 is illustrated as comprising a pair of laterally spaced apart elongated stringers 12 adapted to be disposed between levels of the building, such as for example between an upper floor and a lower floor or between a floor and a landing, and vice versa, as may be present in a split level home, and a plurality of integral riser surfaces 14 and integral tread surfaces 16 extending between the stringers 12 so as to form steps. Each stringer 12 includes an upstanding lower wall 12a, a laterally extending wall 12b and a second upstanding upper wall 12c. The stringer walls 12a, 12b are connected by integral reinforcing gusset 15 proximate the intersection of each riser surface 14 and tread surface 16. A plurality of individual preformed tread members 18 are fastened on the tread surfaces 16 as shown in Figures 5-6 and 8.

The prefabricated stairway is shown including a joist attachment member 20 disposed in a laterally extending channel 22 formed integrally on the rear side of the topmost riser surface 14, Figure 1. The topmost tread surface 16 above the channel 22 may be shortened in depth d compared to the other tread surfaces 16 so that the topmost tread surface is closely spaced to or abuts the floor 30. A correspondingly shortened tread member 18 is fastened on the topmost tread surface 16.

The joist attachment member 20 and channel 22 extend between the stringers 12. The channel 22 is formed integrally with the stringers 12 with the joist attachment member 20 incorporated in-situ in the channel 22 during the molding process described below. The joist attachment member 20 thusly is incorporated into the stairway 10 as an integral part thereof. The joist attachment member 20 can comprise conventional 2X4 lumber (2X4 stud) having a length to extend in channel 22 between the walls 12a of the stringers 12. The channel 22 includes top and bottom walls 22a, 22b, rear wall 22c, and a front wall that is formed by the rear side of the topmost riser surface 14.

The joist attachment member 20 is adapted to receive fasteners, such as lag bolts 25 (one shown), along its length by which the stairway 10 is fastened to a wooden floor or landing joist J as shown in Figure 1. The lag bolts 25 extend through the floor or landing joist J into the attachment member 20. The channel 22 can be drilled through its rear wall 22c to provide holes to receive the lag bolts. The invention is not limited to a joist attachment member 20 made of wood and can be practiced using an attachment member 20 made of plastic material, composite material and others. The attachment member 20 and channel 22 can be formed as a one molded solid integral member. The floor joist J shown can comprise conventional 2X8 or 2X12 lumber used in construction and support of the floor 30 of a building, such as a residential home. The floor 30 is shown comprising a sub-floor 30a and finished floor 30b pursuant to conventional floor construction practice. The joist J

is not limited to the lumber described since the floor or landing joist can comprise other types and sizes of lumber, engineered lumber, steel beams, and any other member used as a floor joist.

As shown in Figure 9, the upper region of the stringers 12 also can be fastened to wall studs WS by screws 34 extending through wall 12c of each stringer 12 into the wall studs. The wall studs typically are used to form a stairwell to receive the stairway 10.

As shown in Figure 1, the lower end of the stairway 10 rests on the lower floor 35, which may comprise a basement floor, a first floor when floor 30 is a second floor, a second floor when floor 30 is a third floor and so on, or a landing of a split level home. As shown in Figure 9, the lower end of the stairway 10 optionally can be fastened in position to wall studs WS by fasteners, such as screws 34, that extend through the wall portion 12c of each stringer 12. Holes can be drilled through the wall 12c, countersunk, and centered on the wall studs to receive the screws 34 to this end.

The tread surfaces 16 are generally flat and horizontal with the exception that they are configured to include an integral reinforcement surface region, such as an integral reinforcement rib 16a extending along a length dimension L of each tread surface 16, Figure 4. The reinforcement ribs 16a have a concave cross-sectional configuration residing below the plane defined by the tread surface 16. Each tread surface 16 is illustrated as having one reinforcement rib 16a generally centrally located on the tread surface. The number and location of integral reinforcement ribs 16a can be varied as desired in practice of the invention. The integral

reinforcement ribs 16a are formed during the resin spraying molding operation described above simply by providing the tread-forming surfaces of the master mold with rib-forming raised projections.

The tread surfaces 16 include a plurality of holes 16c that are adapted to receive fasteners 48 on the tread members. The holes 16c are formed in the tread surfaces 16 by first molding a dimple and then drilling once stairway 10 is removed from the mold. For purposes of illustration only, the holes 16c are formed in a pattern or array shown in Figure 4 to receive the fasteners 48 of the tread member 18 as shown in Figures 6 and 8.

The dimensions of the tread surfaces 16 can be selected as desired for a particular construction application. The tread surfaces 16 typically are of equal depth dimension DT from one tread surface to the next. The topmost tread 16 can be cut to have a shorter depth dimension d to fit an existing building configuration as illustrated in Figure 1. The topmost tread 16 if uncut would extend farther to the right to form a landing at the top of the stairway of Figure 1. The riser surface 14 and adjacent tread surface 16 define an included draft angle A, Figure 1, that can be 91 degrees for purposes of illustration but not limitation as other included angles A can be used.

The stairway 10 can include an optional landing surface (not shown) proximate the top and/or bottom of the stairway. For example, the topmost tread 16 can be extended in a direction to the right in Figure 1 to form a landing surface for the top of the stairway. A preformed landing member similar to a tread member 18

is fastened over the landing surface. Such a landing surface and landing member are described in copending U.S. application 09/711 854 filed November 13, 2000, the teachings of which are incorporated herein by reference.

The stairway can be made by spraying a suitable plastic material on a master mold. For purposes of illustration, the stairway 10 can be made by spraying in a first step, a first outer filled plastic resin layer 45 (Figure 7) using a filled resin system #1 as described in Table #1 through a commercially available two-chamber spray gun (e.g. PRO Series spray gun from manufacturer, Venus Gusmer Inc.) having a static mixer of sufficient length to thoroughly mix filled resin system #1 with a methyl ethyl ketone peroxide catalyst (e.g. High Point 90 by Witco Corporation) as it is sprayed on the surface of the mold. This mixture (i.e. resin system #1 and catalyst) is then allowed to polymerize or cure. The filled resin system #1 (step 1) is sprayed to form outer filled resin layer 45 to have a nominal thickness of about 0.030 inch. Although spraying is the preferred method of application, filled resin system #1 can be hand catalyzed, mixed, and then brushed on or poured on the surface of the mold and allowed to polymerized or cure.

After the aforementioned mixture forming outer filled resin layer 45 has cured, a step 2 involves spraying a second plastic layer 47A behind the first layer 45. The second layer 47A is formed by spraying the resin system #1 as described above on layer 45 immediately followed by spraying filled resin system #2 as

described in Table II and chopped fiberglass fibers through a two-chamber gun of the type described above having a static mixer of sufficient length to thoroughly mix filled resin system #2 with the above catalyst as it is sprayed. This spray gun is also be equipped with a conventional chopper head available from the above manufacturer to cut the fiberglass gun roving into 1" lengths. Both the chopped fibers and the filled resin system #2 are simultaneously sprayed behind the filled resin system #1 at a preferred ratio of 70% by weight of resin and 30% by weight of chopped fiberglass. The mixture is then rolled out and allowed to polymerize or cure to form fiber reinforced filled resin layer 47A. Step #2 described above is repeated twice more to form fiber reinforced filled resin layers 47B and 47C. Each fiber reinforced filled resin layer 47A, 47B, 47C has a nominal thickness of about 0.060 inch. The total thickness of the wall W of stairway 10 thus is about 0.21 inch, although other wall thicknesses can used in practice of the invention. A cross-section through the wall W of the one-piece base 20 is shown in Figure 7.

The joist attachment member 20 is incorporated in the stairway 10 by placing member 20 on the wall W after the layers 47A, 47B, 47C are cured. The member 20 is then sprayed as described above to form additional layers 47A, 47B, 47C on the fastening member 20 to form the channel walls 22a, 22b, 22c in-situ thereabout and thereby incorporate the fastening member 20 into the stairway as integral element thereof.

Table I

Resin System #1

Filled resin system #1 comprises a mixture consisting of 50% by weight of a synthetic plastic resin selected from the polyester or vinyl ester group, (although other thermosetting or other plastic resins may be found suitable), 46% by weight of a wollastonite based product as described in US Patent #4 568 604 and sold under the trademark "KZ6" by Ceramic Technologies Corporation of Rowley Iowa, 2% by weight of the mineral Talc, 1% by weight of a hollow microsphere sold under the trademark "Dualite" by Pierce and Stevens Corporation of Buffalo NY, and 1% by weight Titanium Dioxide. It will be understood by those skilled in the art that the above mixture has been found to be preferred but that deviation from the percents listed or the filler or other constituents used is within the scope of this invention.

Table II

Resin System #2

Resin system #2 comprises a mixture consisting of 75% by weight of a synthetic plastic resin selected from the polyester or vinyl ester group, (although other thermosetting plastic resins may be found suitable), 21 1/2% by weight of a wollastonite based product as described in US Patent #4 568 604 and sold under the trademark "KZ9" by Ceramic Technologies Corporation of Rowley Iowa, 2% by weight of the mineral Talc, 1/2% by weight of a hollow microsphere sold under the trademark "Dualite" by Pierce and Stevens

Corporation of Buffalo NY, and 1% by weight Titanium Dioxide. It will be understood by those skilled in the art that the above mixture has been found to be preferred but that deviation from the percents listed or the filler or other constituents used is within the scope of this invention.

It will be noted that the filled resin system #1 and filled resin system #2 each contain the catalyst described above so that the layers 45, 47A, 47B, 47C comprising the stairway wall W cure on the mold without the need for heating to this end.

The resin system #1 without chopped fibers and resin system #2 with chopped fiberglass fibers as described above are sprayed on a one piece, open-bottom master mold (not shown). The master mold is fabricated of the same material layers as described above sprayed on a master wooden pattern having a shape corresponding to that of the stairway 10. The fabricated master mold is provided with a draft angle of 9 degrees (or other suitable draft angle) that is imparted to the stairway 10 as a 9 degree top-to-bottom draft angle on each of the stringers 12 and risers 14. This draft angle allows the sprayed, cured stairway 10 to be removed vertically from the mold out of the open bottom of the mold, the stairway 10 being sprayed with the tread surfaces 16 oriented to face downwardly.

The preformed tread members 18 and the landing member (not shown), if used, typically are molded by applying (e.g. spraying, brushing and the like) a product sold under the trademark "KZ Ceramic Gelcoat", and taught in US Patent #5 688 851, herein called "KZ Gelcoat", mixed with the above catalyst to the surface of a

face-mold of a two-part mold and allowed to polymerize or cure to provide a layer nominal thickness of about 0.030 inch. Then, multiple layers (usually 2 to 4) of continuous fiberglass mat M, Figure 6, are placed in the face-mold behind the cured "KZ Gelcoat", the mold is then closed by clamping, bolting or otherwise connecting a rear-mold to the face-mold and filled with the above filled resin system #2 mixed with the above catalyst and allowed to polymerize or cure. The thickness of each tread member 18 and landing member, if used, is nominally about 0.20 inch.

The tread members 18 and landing member can be individually molded in a conventional two-part cavity mold comprising a face-mold and rear-mold mate-able to form a closed cavity, such as is used in RTM (Resin Transfer Molding) or compression molding. Other molding techniques, which can be used, include but are not limited to injection molding, low pressure composite molding, and other conventional molding processes.

The tread members 18 and landing member, if used, are molded to capture integrally therein a plurality of threaded fasteners 48 each having enlarged fastener head 48a and a threaded shank 48b, Figure 6. The fasteners 48 are captured in each tread member by placing the head of the fastener between the aforementioned layers of the fiberglass mats M before molding. Capturing of the fasteners 48 in this manner is advantageous to hide the fasteners from view when the stairway 10 is assembled.

The tread members 18 and the landing member, if used, are molded to include integral pilot protrusions 18p on the underside thereof and adapted to be received in a respective hole 16c in the underlying tread surface 16 and landing surface.

The tread members 18 are also molded to include an integral bull nose 18n that depends or extends downwardly about the front periphery of the tread member to overlap and hide the adjacent riser surface 14 located therebelow as will be appreciated from Figure 8. The rear periphery of each tread member 18 comprises a straight edge 18e. The bull nose 18n includes a straight lip region 18nl and a radius region 18nr.

The landing member, if used, is also molded to include an integral bull nose that depends or extends downwardly about the front periphery of the landing member to overlap and hide the adjacent riser surface 14 located therebelow.

The bull noses 18n on the tread members 18 and landing member, if used, provide an aesthetically pleasing appearance to the stairway when assembled.

The tread members 18 and landing member can be made of materials other than plastic material described above. For example, the invention envisions making the tread members 18 and landing member, if used, out of wood, metal, and other suitable materials using conventional wood working, metal working and other techniques.

The tread members 18 are fastened to the respective tread surfaces 16 by inserting the threaded shank 48b of the fasteners 48 through the holes 16c and assembling and tightening a nut 52 on the shank 48b with a washer 53 positioned between the nut 52 and the underside of the tread member, Figure 6. The landing member, if used, can be fastened in like manner to a landing surface provided on the stairway 10.

The tread members 18 and the landing member, if used, can be molded to provide an anti-slip surface on the upper surface thereof. A diamond anti-slip surface pattern for purposes of illustration only can be molded into the entire upper surface of the tread members 18 and landing member, if used, if desired as described in U.S. Serial No. 09/711 854 filed November 13, 2000, incorporated herein by reference. Other anti-slip surfaces can be molded into the upper surfaces of the tread members and/or the landing member to suit a particular construction application. Moreover, the tread members 18 and landing member, if used, can be molded to impart any desired decorative appearance thereto. For example, they can be molded to have a stone, brick or other desired surface appearance. Still further, the color of the tread members and the landing member can be selected to provide any desired aesthetic appearance. For example, the color of the tread members 18 and landing member can be different from that of the stairway 10 and matched to the color of the building or structure.

In use, should a tread member 18 or a landing member, if used, become damaged for some reason, it can be removed from the stairway 10 by removing the nuts 52 and washer 53 and then fastening a replacement tread member or landing member in its place.

The stairway 10 can be installed in a stairwell formed by wall studs WS in conventional manner as shown in Figure 9. The upper end of the stairway 10 can be fastened to the floor joist J as shown in Figure 1 and described above. The upper region of the stringers 12 also can be fastened to the wall studs WS by screws 34 extending

through wall 12c of each stringer 12 into the wall studs. The lower end of the stairway 10 can be fastened to wall studs WS located proximate stringers 12 using like screws 34 extending through walls 12c of each stringer 12. A filler strip or shim lathe 60 is nailed on the wall studs WS to be flush with the wall 12c of each stringer 12 as shown. Sheet rock (also known as dry wall sheet) 62 is then nailed on the filler strip or shim lathe 60 to overlap the stringer wall 12c as shown in Figure 9. A bead of caulk 64 then can be applied to complete the joint between the stairway 10 and the sheet rock 62. A handrail 70 mounted on bracket 72 is fastened to the wall studs WS using screws 72 extending through the bracket 72 into the wall studs as shown. The handrail can extend the length of the stringers 12.

Referring to Figures 10-13, a free-standing stairway 10' pursuant to another embodiment of the invention is illustrated. In Figures 10-13, like features of Figures 1-9 are represented by like reference numerals primed.

The stairway 10' includes stringers 12' that each include upstanding inner wall 12a', a lateral wall 12b', and a downwardly extending outermost wall 12d', with the walls 12b' being molded to include receptacles 13a' and 13b' for receiving the lower ends of ballaster posts 80' and newel posts 82', respectively, that support a handrail 84'. The outermost wall 12d' extends downwardly to provide the outer visible wall of the stairway. Although not shown in Figures 10-13, reinforcing gussets similar to gussets 15 of Figures 1-9 are provided on stairway 10'. The receptacles 13a' are

sized and shaped to receive the lower ends of the ballaster posts 80', while the receptacles 13b' are sized and shaped to receive the lower ends of the newel posts 82' as shown in Figure 12. The lower ends of the posts 80' and 82' are fastened in the receptacle 13a', 13b' by suitable adhesive and/or by a screw (not shown) extending upwardly through a hole 17' drilled in the bottom of each receptacle 13a', 13b' (only some of the holes 17' being shown for the receptacles 13b'). The ballaster posts, newel posts and handrail can be made of wood, metal (e.g. wrought iron), plastic material and other materials.

The upper region of the stairway 10' can be fastened to the upper floor 30' via its floor or landing joist J'. The lower region of the stairway 10' can rest on the lower floor 35' and be fastened to the floor by a screw (not shown) extending through the bottom of each ballaster receptacle 13a' for fastening to the floor or landing 35', which can be wood, concrete or other floor conventional floor material. The type of screw used to fasten the stairway on the floor or landing 35' would be selected in dependence on the floor or landing material present. If the ballaster posts are glued in the receptacles 13a', the floor screw can extend through hole 17'. An additional screw hole (not shown) can be provided otherwise in the bottom of receptacle 13a'.

A decorative cover panel 100' can be attached by screws 102' to lowermost (bottom) edges of stringer outer walls 12d' to hide the bottom of the stairway from view, Figures 10 and 13. The channel 22' may include chamfered corner 22e' to accommodate the cover

panel 100' as illustrated in Figure 10. The cover panel 100' can be made of sheet rock (drywall), wood or composite wood paneling, plastic paneling material or any other panel material.

Although not shown in Figures 10-13, it is understood that the tread surfaces 16' of stairway 10' will have fastened thereon as described above a respective tread member like tread member 18 of Figure 8 to complete the stairway 10'.

Referring to Figures 14-16 where like features of previous figures are represented by like reference numerals double primed, an embodiment of the invention envisions fastening one or more of the tread members 18'' on a tread T'' of one or more steps S'' of an existing stairway SW'' made of wood (Figure 14), concrete (Figure 15), metal (e.g. steel, Figure 16) and other materials. One or more tread members 18'' can be fastened to refurbish one or more worn or damaged treads of the stairway between the stringers ST''. Alternately, one or more safety-colored (e.g. yellow, orange, red, etc,) tread members 18'' having a color different from the color of the steps S'' can be fastened to one or more steps S'' to enhance the visual appearance of the step(s) for aesthetic and/or safety purposes. The tread members 18'' can be fastened to the treads T'' by any appropriate means such as threaded fasteners 48'', nuts 52'', and washers 53'' as illustrated in Figures 14-16, adhesive, and/or other suitable fastening technique. The tread members 18'' can be molded or post-mold drilled as described above to include holes 18c'' to receive the fasteners 48', rather than having the fasteners captured integrally in the tread member 18''. The treads T'' can be conventionally drilled to provide holes H''

to receive the fasteners 48''. Alternately, if the thread members 18'' will be adhesively attached to the steps S'', the holes 18c'' may be omitted. Each tread member 18'' can include the bull nose 18n'' that overlaps the adjacent riser surface of the step S'' and a straight edge 18e'' at the rear of the tread member 18''. The tread members 18'' can be molded without or with the pilot protrusions 18p, Figure 6, described above. Otherwise, the tread members 18'' have a cross-section similar to that of Figure 6. In Figures 14-16, the pilot protrusions are omitted from the tread members 18''.

Figure 15 illustrates a landing member 19'' to be fastened on the top landing surface L'' of the concrete stairway SW''. The landing member 19'' is molded or drilled to include holes 19c'' in the same manner described above for the tread members 18 and can be fastened on the stairway landing surface L' using fasteners 48'' through holes 19c'', nuts 52'' and washer 53'' as described for the tread members 18'', adhesive or any other suitable fastening technique as described for the tread members 18''. The landing member 19'' includes a bull nose 19n'' around its entire periphery.

The present invention is advantageous to provide an improved prefabricated stairway for use between floors of a building or other structure where the stairway is relatively lightweight to facilitate transport to and proper positioning at the building or structure site and yet sturdy enough to withstand loads encountered in use, is resistant to wear and chemicals, and offers improved

stairway aesthetics. Also, the invention envisions fastening one or more tread members on worn steps to refurbish the steps and/or to enhance the visual appearance of the step(s) for aesthetic or safety purposes.

Although the invention has been described with respect to certain specific embodiments, it is not limited thereto and can be modified and changed within the scope of the appended claims.

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2205
2206
2207
2208
2209
2210
2211
2212
2213
2214
2215
2216
2217
2218
2219
2220
2221
2222
2223
2224
2225
2226
22